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ENERGY SAVINGS OPPORTUNITY SURVEY (MODIFIED)

Final Report:

FORT CARSON, COLORADO

Prepared for:

U.S. Army Engineer District, Omaha
Corps of Engineers
Omaha, Nebraska

Contract No. DACA45-84-C-0125

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Volume 1

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PREFACE

This report is the final submission of Energy Savings Opportunities (Modified) at Fort Carson, Colorado. The report was prepared by Forster-Morrell Engineering Associates, Inc. of Colorado Springs, Colorado, and its consultants, Computer Applications and Engineering Resources, Inc. of Golden, Colorado. The project is under the direction of the Department of the Army, Omaha District Corps of Engineers in accordance with the requirements of Contract No. DACA45-84-C-0125. The intent of the study is to identify and develop cost effective energy conservation projects for Fort Carson.

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EXECUTIVE SUMMARY

Objective

The objective of the energy conservation study at Fort Carson is to determine the feasibility of Energy Conservation Opportunities (ECOs) as specified in the Scope of Work. The criteria for a qualifying ECO is a Savings-to-Investment Ratio (SIR) greater than or equal to 1 (SIR >= 1). ECOs are numbered, defined and listed in Table ES.2, on page ES-4.

Authority and Scope

The contractual authority for this specific study is contract No. DACA45-84-C-0125. The Scope of Work lists seven elements of work to be accomplished.

(1) Review previous studies (by Burns and McDonnell).

(2) Reevaluate selected projects (ECOs 1, 2, 19 and 34 as applied to eight temporary buildings).

(3) Evaluate selected ECOs:
   a. 14 primary and 536 similar Military Family Housing (MFH) buildings for a total of 1,827 housing units.
   b. 29 primary and 63 similar temporary buildings.
   c. 23 primary and 94 similar permanent buildings.
   d. 13 primary and 166 similar permanent buildings to be evaluated for applicability for Energy Monitoring and Control System (EMCS) and Low Cost Alternatives (LCA).

(4) Perform a limited site survey: survey the designated buildings for application of the ECOs in Table ES.2, acquire the data necessary to support the energy analysis, and identify the local loop controls that need repair or replacement in the 179 buildings to be evaluated for the EMCS.

(5) Provide programming or implementation documentation for projects (ECIP, PECIP, QRIP) developed during this study.

(6) Training and expendable equipment replacement: describe any training required in energy related areas of maintenance and operation, and describe expendable equipment that should be changed to a higher efficiency type at the next replacement.

(7) Submittals, presentations and reviews: fully document the work with a comprehensive report.

Project Summary

Eleven projects are recommended for funding at the Fort Carson installation. Seven ECIP, three QRIP and one PECIP funding projects indicate a combined annual energy cost savings of $2,974,748. Total recommended FY 88 ECIP project costs equal $16,279,000 while the QRIP and PECIP projects have a combined Jan. 1985 through July 1985 investment cost of $538,758.

TABLE ES.1
SUMMARY OF RECOMMENDED PROJECTS

FUNDING PROGRAM & PKG #	BLDG. GROUP	ANNUAL ENERGY SAVINGS (MBTU) (NG)	(ELEC)	ANNUAL COST SAVINGS $	ESTIMATED INVESTMENT COST $ (1985)	SIR	SIMPLE PAYBACK
ECIP-5	PERM	60,053	8,351	288,032	1,580,705	3.71	5.4
ECIP-4	PERM	133,018	2,683	587,212	2,231,098	3.27	4.3
ECIP-8	MFH	37,790	12,412	201,262	2,155,725	1.87	10.2
ECIP-1	PERM	56,214	0	247,596	2,572,861	1.79	12.8
ECIP	TEMP	31,685	249	144,702	810,284	1.58	5.8
ECIP-9	MFH	14,847	0	67,530	713,506	1.58	7.5
ECIP	EMCS	248,002	37,538	1,097,081	3,879,384,	3.70	3.5
TOTAL ECIP		581,609	61,233	2,633,415	13,943,563		
QRIP-N	TEMP	15,075	0	68,566	77,826	8.28	1.1
QRIP-M	TEMP	9,130	0	41,526	47,337	8.21	1.1
QRIP-S	TEMP	14,130	45	64,375	88,669	6.77	1.3
PECIP	TEMP	24,744	152	112,902	324,926	3.23	2.8
TOTAL NON-ECIP		63,079	197	287,369	538,758		

Method of Analysis

Extensive field surveys were conducted to determine the applicability of selected ECOs and contractor-defined ECOs, and to acquire the data to support calculations and analysis.

Computer programs (BLAST 3, QUIKEE or BCEP) were used to first model existing conditions and then to determine effects of each applicable ECO for the primary buildings; hand calculations were used when appropriate. An economic analysis was made for each ECO on each primary building to establish ECO qualification status under the current ECIP guidelines.

Coordination meetings resulted in selected ECIP, QRIP and PECIP projects consisting of grouped ECOs. The groups of ECOs were evaluated by computer on the primary buildings and the effectiveness of each individual ECO was established taking all overlapping effects into account. Projects were modified to include only qualifying ECOs, and the results were extended to the similar buildings.

The EMCS study methodology is somewhat different and involves the application of ECO #42 to 171 designated buildings. Eight of the 179 buildings listed in the Scope of Work are either not in use, or not conditioned. Each primary building was modelled with a computer program to obtain energy consumption for the existing conditions.

Each of the 171 buildings was surveyed and potential EMCS functions were identified. The energy savings were calculated using a computer program, Facilities Automation Controls Evaluation (FACE) which follows the method developed in "Standardized EMCS Energy Savings Calculations" by Newcombe and Boyd Architects and Engineers. The method was developed for the Naval Civil Engineering Laboratory in 1982 and has been approved by the Army Corps of Engineers. FACE uses a number of energy constants derived from energy consumption simulations of the primary buildings. These constants were then modified for each similar building. An economic analysis of the cost effectiveness of each EMCS function for each mechanical system was made.

A Low Cost Alternative (LCA) study was accomplished to provide an alternative approach that produces most of the energy savings of the EMCS. The analytical procedure is the same as that used for the EMCS study. The LCA system provides all of the energy savings that the EMCS does with the single exception of electrical demand limiting. Essentially the LCA configuration employs the stand-alone, distributed control units of the EMCS without the master control room equipment and software, and without the extensive data transmission media of the EMCS.

TABLE ES.2
MASTER ECO LIST

Master List No.	ECO DESCRIPTION
1	Insulation (walls, ceilings, roofs, crawlspace, slabs)
2	Storm windows or double glazing
3	Weatherstripping and caulking
4	Insulated panels
5	Vestibules or revolving doors
6	Load dock seals/air curtains/strip doors
7	Reduction of glass area
8	*Replace kitchen light fixtures
9	Shutdown, modify or replace hw heaters
10	Reduce lighting levels
11	*Replace incandescent lighting
12	*Use more efficient lighting source
13	High efficiency motor replacement
14	Night setback/setup thermostats
15	Infrared heaters (shops and warehouses)
16	Economizer cycles (dry bulb types)
17	Control hot water circulation pumps
18	FM radio controls
19	Radiator controls
20	Point-of-use hot water heaters
21	Heat reclaim from hot refrigerant gas
22	Reduce air flow
23	Prevent air stratification
24	Install time clocks
25	Chiller replacement
26	Replace absorption chiller
27	Insulate steam lines
28	Return condensate
29	Transformer over voltage
30	Transformer loading
31	Revise or repair HVAC controls
32	Waste heat recovery
33	Add additional light switches
34	HVAC initiatives
35	Exterior lighting control (photocells)
36	Boiler oxygen trim controls
37	Revise boiler controls
38	Preheat domestic hot water
39	Heat pumps
40	High pressure sodium street lights
41	Electric outlet insulation
42	Energy Monitoring and Control System (EMCS)

* ECO #8, 11 and 12 are combined in 12

Summary of EMCS Results

Appropriated Fund (O & M) Buildings:

161 non-reimbursable utilities buildings were analyzed for the application of a large EMCS system; 128 buildings qualified under the ECIP criteria. The reimbursable utilities buildings were analyzed separately and are shown below. Figure ES-1 is the EMCS schematic for the qualifying buildings. The system is recommended for ECIP funding in FY 1988. This project was analyzed from January through July 1985 and the programmed FY 88 cost is $4,530,000.

The major features of the EMCS are summarized below.

No. of Buildings		128
Length of buried cable		69,700 ft.
No. of line drivers		43
No. of modems		2
No. of FIDs		35
No. of MUX panels		93
No. of DE points		5,739
Annual electrical savings	(MBTU)	37,538
	($)	86,976
Annual natural gas savings	(MBTU)	248,002
	($)	1,064,069
Annual maintenance cost		$ 60,882
Annual electrical demand savings		$ 6,918
Net annual cost savings		$1,097,081
Total EMCS investment cost		$3,879,384

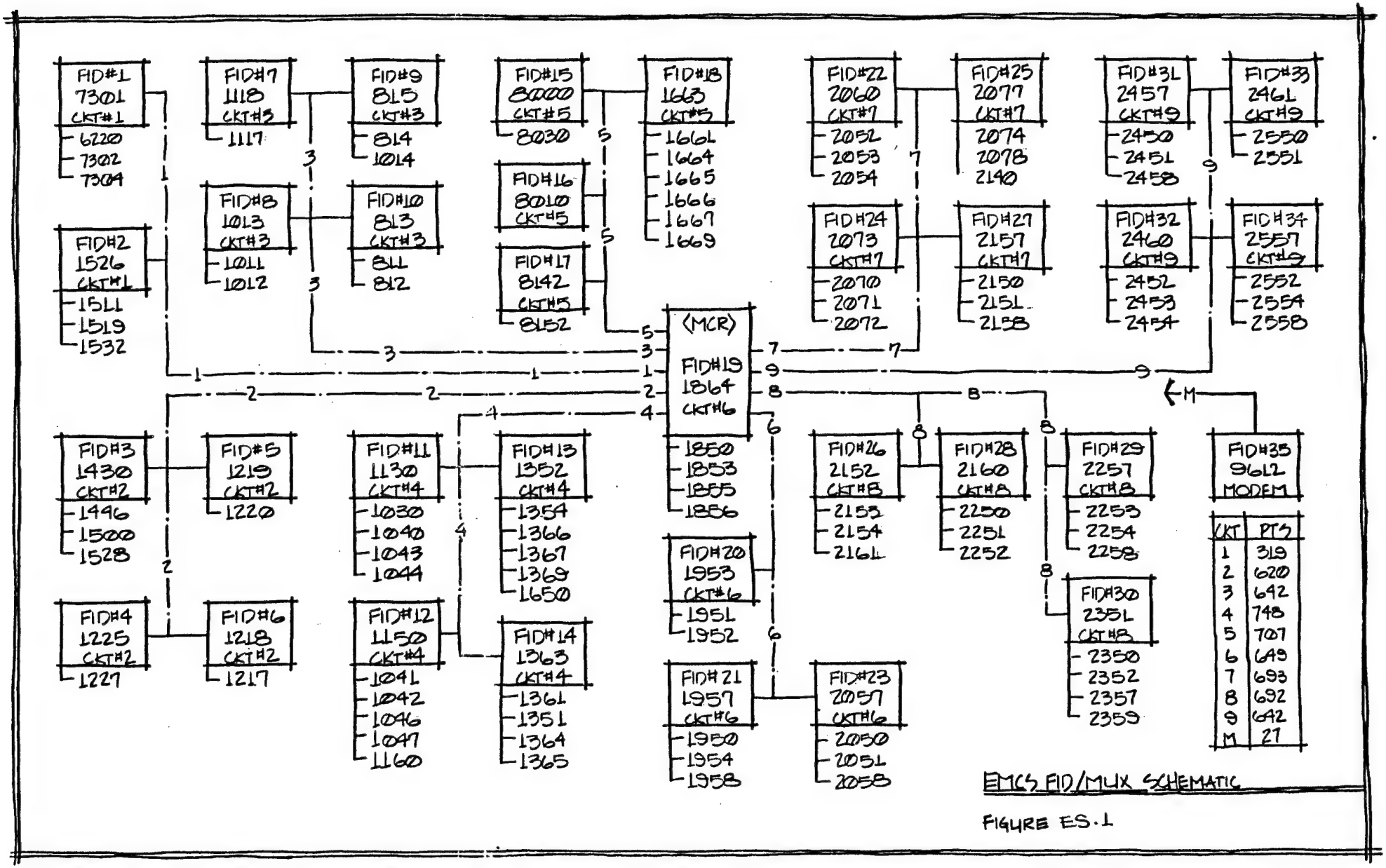
Simple payback period = 3.5 years
SIR = 3.7

The Project Development Brochure and DD 1391 are completed and submitted.

The performance of the EMCS depends in a major way on the working condition of the local loop control elements. The repair and maintenance of these controls is an ongoing job that must be completed for any system to function properly. Each building was surveyed for broken or damaged controls and actuators to provide a reasonable and probable cost of repair, calibration and adjustment on the EMCS buildings. The estimated repair work cost is established to be $246,671 and should be included in the O&M budget for FY 88.

Reimbursable Utilities Buildings:

Ten designated buildings were analyzed for connection to the large EMCS described above. The project to connect the buildings to the EMCS is not a candidate for ECIP funding since the utility costs are paid by the tenants. However, the analysis using the



EMCS FID/MUX SCHEMATIC

FIGURE ES.1

ECIP criteria is included to aid Ft Carson in the event they wish to add these buildings to the large EMCS. This project was analyzed from January through July 1985. The results are summarized below.

Number of buildings	10	
Number of FIDs	2	
Number of MUX panels	8	
Length of DTM lines	2,940	feet
Number of DE points	568	
Annual electrical savings	3,337	MBTU/$7,067
Annual natural gas savings	14,306	MBTU/$60,908
Annual maintenance cost	$ 8,997	
Net annual avoided cost	$ 58,978	
Total Investment Cost	$179,945	
Simple payback period	3.2	years
SIR	4.4	

It is recommended that this system be connected to the large EMCS for the 128 qualifying O&M buildings.

Summary of LCA Results

Appropriated Fund (O & M) Buildings:

The 161 O&M buildings were analyzed for the application of the LCA. 126 buildings qualified under current ECIP criteria. The system is not recommended for implementation, as the loss in maintenance reporting capability and centralized alarm notification outweigh the $910,733 investment cost savings over the EMCS. Major features and performance are summarized below.

Number of buildings	126	
Length of buried cable	27,110	feet
Number of line drivers	0	
Number of modems	0	
Number of FIDs	38	
Number of MUX panels	88	
Number of DE points	5,712	
Annual electrical savings	37,434	MBTU/$88,614
Annual natural gas savings	247,237	MBTU/$1,059,374
Annual maintenance cost	$ 148,433	
Net annual cost savings	$ 851,103	
Total LCA investment cost	$2,968,651	
Simple payback period	3.1	years
SIR	4.6	

Reimbursable Utilities Buildings:

The 10 reimbursable utilities (RU) buildings were analyzed for avoided costs in connection with adding them onto the large LCA

for the 126 O&M buildings described above. Eight of the buildings show simple payback periods of less than 10 years. This project was analyzed from January through July 1985. The results for all 10 buildings are summarized below.

Number of buildings	10	
Number of FIDs to be purchased	3	
Number of MUX panels	6	
Length of DTM lines	1,440	feet
Number of DE points	568	
Annual electrical savings	3,337	MBTU/$6,036
Annual natural gas savings	14,306	MBTU/$60,908
Annual maintenance cost	$ 8,694	
Net annual avoided cost	$ 58,250	
Total Investment Cost	$173,884	
Simple payback period	3.1	years
SIR	4.5	

This system is recommended for implementation with O&M funds only in the event the large LCA system is installed.

Summary of ECO Projects

Three methods of funding were examined for all of the qualifying ECOs (SIR >= 1.0). ECIP funding is available for a package of ECOs with an SIR greater or equal to 1.0 and with a total investment cost of at least $200,000. QRIP funding is available for a package of ECOs with a simple payback of 2 years or less and a total investment cost of not over $100,000. PECIP funding is available for a package of ECOs with a simple payback of 4 years or less and a total investment cost of over $3,000. QRIP and PECIP funding is based on simple payback and not on SIR as is ECIP. The eight temporary buildings which required the reevaluation of four select ECOs are included with the Temporary Buildings ECO packages.

ECIP Funding Projects:

ECIP projects for MFH units and Post Military Construction Army (MCA) O&M buildings are funded separately, each under its own appropriation.

Seven ECO projects are recommended for ECIP funding in FY 1988. The projects were separated, for the most part, by expected economic life and by the type of retrofit work required (i.e. architectural, HVAC, electrical). Each project is summarized in a table below with its respective discrete portion (ECO) economic results shown by order of SIR. The investment costs include the construction costs plus a 5.5% SIOH. Each project was analyzed during Jan. 1985 through July, 1985.

MFH Buildings:

ECOs for 550 military family housing (MFH) buildings which qualify under the ECIP criteria were placed in two funding projects. Table ES.3 contains three discrete portion and total project results for 25 year life ECOs. Table ES.4 contains similar data for the single ECO having a 15 year life. The programmed FY 88 costs are $2,517,000 and $833,000 respectively.

TABLE ES.3

PROJECT SUMMARY - DISCRETE PORTION RESULTS

MFH PACKAGE #8 - ECIP PROJECT

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ELEC ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
3	11,088	0	50,430	295,996	2.81	8.4
12	0	12,412	29,382	285,156	2.11	5.6
1	26,702	0	121,450	1,574,573	1.65	12.3
TOTAL	37,790	12,412	201,262	2,155,725	1.87	10.2

TABLE ES.4

PROJECT SUMMARY - DISCRETE PORTION RESULTS

MFH PACKAGE #9 - ECIP PROJECT

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
9	14,847	67,530	713,506	1.58	7.5
TOTAL	14,847	67,530	713,506	1.58	7.5

Permanent Buildings:

Architectural ECOs for 83 permanent buildings qualify under the ECIP criteria. Table ES.5 contains four discrete portion results and the total project results for 25 year life ECOs. The programmed FY 88 cost is $3,004,000.

Heating, ventilating and air conditioning (HVAC) ECOs for 103 permanent buildings qualify under the ECIP criteria. Table ES.6 contains six discrete portion and total project results for 15 year life ECOs. The programmed FY 88 cost is $2,605,000.

Plant and lighting ECOs for 69 permanent buildings qualify under the ECIP criteria. Table ES.7 contains five discrete portion and total project results for 25 year life ECOs. The programmed FY 88 cost is $1,846,000.

TABLE ES.5

PROJECT SUMMARY - DISCRETE PORTION RESULTS

PERMANENT BUILDINGS PACKAGE #1 - ECIP PROJECT

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
3	16,916	73,729	372,477	2.40	20.5
2	26,892	117,905	1,311,067	1.92	10.5
4	1,182	5,163	74,379	1.48	13.7
1	11,224	50,799	814,938	1.33	15.2
TOTAL	56,214	247,596	2,572,861	1.79	12.8

TABLE ES.6

PROJECT SUMMARY - DISCRETE PORTION RESULTS

PERMANENT BUILDINGS PACKAGE #4 - ECIP PROJECT

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ELEC ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
24	242	121	1,371	1,981	8.42	1.5
31	20,662	249	90,154	179,616	6.13	2.3
14	60,192	2,303	264,843	681,197	5.23	2.6
16	663	10	2,846	11,037	3.61	3.7
23	212	0	964	6,414	2.11	6.3
19	51,047	0	227,033	1,350,853	1.89	7.9
TOTAL	133,018	2,683	587,212	2,231,098	3.27	4.3

TABLE ES.7

PROJECT SUMMARY - DISCRETE PORTION RESULTS

PERMANENT BUILDINGS PACKAGE #5 - ECIP PROJECT

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ELEC ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
9	25,816	12	112,572	61,821	38.80	0.5
35	0	2,166	5,127	13,011	4.17	3.0
12	0	5,256	12,442	54,775	2.97	4.0
34	17,583	0	79,972	651,352	2.49	8.5
32	16,654	0	75,747	774,752	2.07	9.9
13	0	917	2,171	24,995	1.08	10.9
TOTAL	60,053	8,351	288,032	1,580,705	3.71	5.4

Temporary Buildings:

Architectural, HVAC, plant and lighting ECOs for 33 temporary buildings qualify under the ECIP criteria. All of the ECOs were combined in one ECIP project due to the maximum 10 year expected life of the temporary buildings. Table ES.8 contains fourteen discrete portion and total project results for 10 year life buildings. The programmed FY 88 cost is $944,000.

TABLE ES.8

PROJECT SUMMARY - DISCRETE PORTION RESULTS

TEMPORARY BUILDING PACKAGES #2, #3, #6, #7 - ECIP PROJECT

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ELEC ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
23	995	0	4,526	7,483	5.75	1.57
14	3,083	0	14,022	35,702	3.49	2.63
19	6,944	0	31,583	118,813	2.24	4.17
9	99	16	488	2,189	2.08	4.25
3	776	0	3,529	12,552	1.96	5.02

TABLE ES.8 (Continued)

PROJECT SUMMARY - DISCRETE PORTION RESULTS

TEMPORARY BUILDING PACKAGES #2, #3, #6, #7 - ECIP PROJECT

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ELEC ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
12	0	233	552	2,557	1.79	4.04
21	169	0	769	3,391	1.72	5.65
27	1,444	0	6,568	35,714	1.48	6.40
1	5,615	0	25,539	174,556	1.39	6.48
31	359	0	1,633	11,379	1.36	6.61
2	1,946	0	8,856	63,890	1.31	6.84
34	10,091	0	45,897	335,029	1.20	7.62
5	17	0	77	723	1.01	8.86
4	147	0	669	6,305	1.01	8.94
TOTAL	31,685	249	144,702	810,284	1.58	5.81

QRIP Funding Projects:

The buildings involved in this analysis are all temporary and have a maximum economic life of 10 years. The QRIP funding criteria requires a maximum simple payback of 2 years or less and a maximum investment cost of $100,000. The three QRIP projects have a total investment cost of $202,615 and are divided by geographic area (north area, mid area, south area). The investment cost includes the construction cost plus a 5.5% SIOH. The QRIP projects were analyzed during Jan. 1985 through July, 1985 and are recommended for implementation during the next funding cycle.

Table ES.9 contains five discrete portion and total project results applicable to 23 temporary buildings. The project is composed of HVAC ECOs.

Table ES.10 contains three discrete portion and total project results applicable to 4 temporary buildings. The project is composed of HVAC ECOs.

Table ES.11 contains four discrete portion and total project results applicable to 15 temporary buildings. The project is composed of HVAC and electrical ECOs.

TABLE ES.9

PROJECT SUMMARY - DISCRETE PORTION RESULTS

TEMPORARY BUILDING PACKAGES #2, #3, #6, #7 - QRIP PROJECT

NORTH AREA

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
14	4,488	20,413	12,258	15.70	0.57
31	4,121	18,744	14,479	12.20	0.74
34	6,232	28,345	47,330	5.60	1.62
23	124	564	1,069	5.02	1.80
9	110	500	2,690	1.76	5.10
TOTAL	15,075	68,566	77,826	8.28	1.09

TABLE ES.10

PROJECT SUMMARY - DISCRETE PORTION RESULTS

TEMPORARY BUILDING PACKAGES #2, #3, #6, #7 - QRIP PROJECT

MID AREA

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
14	2,650	12,053	3,716	30.73	0.29
34	6,079	27,649	39,345	6.54	1.39
23	401	1,824	4,276	4.05	2.22
TOTAL	9,130	41,526	47,337	8.21	1.10

TABLE ES.11

PROJECT SUMMARY - DISCRETE PORTION RESULTS

TEMPORARY BUILDING PACKAGES #2, #3, #6, #7 - QRIP PROJECT

SOUTH AREA

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ELEC ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
14	2,830	0	12,872	11,029	10.91	0.83
19	1,451	0	6,600	7,426	8.16	1.12
34	9,849	0	44,786	69,699	6.00	1.51
12	0	45	107	515	1.93	3.74
TOTAL	14,130	45	64,374	88,669	6.77	1.34

PECIP Funding Projects:

The buildings involved in this analysis are all temporary and have a maximum economic life of 10 years. The PECIP funding criteria requires a maximum simple payback of 4 years or less and a minimum investment cost of $3,000. The single PECIP project has a total construction cost of $307,987. The investment cost includes the construction cost plus a 5.5% SIOH. The PECIP project was analyzed during Jan. 1985 through July, 1985 and is recommended for implementation during the next funding cycle.

Table ES.12 contains ten discrete portion and total project results applicable to 27 temporary buildings. The project encompasses architectural, HVAC and electrical ECOs.

TABLE ES.12

PROJECT SUMMARY - DISCRETE PORTION RESULTS

TEMPORARY BUILDING PACKAGES #2, #3, #6, #7 - PECIP PROJECT

ECO #	ANNUAL NAT GAS ENERGY SAVINGS (MBTU)	ANNUAL ELEC ENERGY SAVINGS (MBTU)	ANNUAL ENERGY COST SAVINGS ($)	ESTIMATED INVESTMENT COST ($) (1/85)	SIR	SIMPLE PAYBACK (YRS)
14	7,920	0	36,023	30,003	11.29	0.80
3	75	0	400	481	6.03	1.54
9	208	0	946	2,689	7.06	2.69
12	0	152	360	1,173	2.56	2.83
19	480	0	2,183	5,941	3.20	2.88
27	298	0	1,355	4,584	2.81	3.21
23	651	0	2,961	10,690	2.63	3.42
34	15,021	0	68,320	266,466	2.37	3.83
31	59	0	268	1,626	1.57	5.74
5	32	0	86	1,273	1.08	8.29
TOTAL	24,744	152	112,902	324,926	3.23	2.81

Project Documentation

The required project documentation for each of the projects described above has been completed and submitted.

EMCS EXECUTIVE SUMMARY

Objective

The objectives of the Energy Monitoring and Control System (EMCS) study at Fort Carson are threefold:

a) Determine the physical practicality of installing an EMCS that meets the Army requirements set forth in TM5-815-2 dated June 1983, and in CEGS-13947 dated September, 1984.

b) Determine the cost effectiveness in accordance with current Energy Conservation Investment Program (ECIP) criteria.

c) Define a Low Cost Alternative (LCA) to the EMCS and determine its cost effectiveness.

Authority and Scope

The contractual authority for this specific study is Contract No. DACA45-84-C-0125. 179 buildings are designated in the Scope of Work to be included in the study. Eight buildings are either not in use or unconditioned. The study encompasses 171 buildings: 161 O & M buildings and 10 reimbursable utilities buildings. Each group is studied for the application of an EMCS and a Low Cost Alternative system.

General Approach

The previous EMCS study accomplished by Burns & McDonnell in 1980 was reviewed for content and method of approach. Each of the 179 buildings designated for this study was inspected to validate data on as built drawings and to acquire functional use and operation data required for the analyses. Local loop controls and actuators were surveyed to determine O & M repair costs. Each mechanical/electrical system in each building was surveyed to determine the potential application of the various EMCS control and monitor functions.

The potential energy savings for the various EMCS control functions were calculated using the approved method set forth by Newcomb & Boyd in "Standardized EMCS Energy Savings Calculations", 1982. Certain energy parameters in the Newcomb & Boyd method must be determined, which vary according to building shell characteristics and the type of mechanical system. The 171 buildings were divided into 13 groups according to building construction features and mechanical/electrical system similarities. A primary building was designated for each group, and studied in detail using computer simulation to accurately calculate the energy parameters required for the EMCS energy savings calculations. The algorithms for the calculations have been programmed (Facilities Automated Controls Evaluation,

(FACE)), and each building was evaluated for energy savings by EMCS function on each mechanical/electrical system. The energy savings for each system in each of the 171 buildings were calculated using the FACE program. Special attention was given to ensure realistic results. Maximum savings are on the order of 25% to 50% depending on the existing conditions in each building. Overall, the calculated energy savings should be somewhat conservative.

The economic analysis was made by first laying out the architecture for a large system:

- -Master Control Room (MCR) located in Building 1364.
- -Location of Data Transmission Media (DTM) trunk lines, slave lines, and line drivers.
- -Location of FIDs and MUXs by building.
- -Listing of the required sensors and controls in the Data Environment (DE) of each building.

Figure ES-1 shows the EMCS schematic for the 128 qualifying buildings. Cost estimates for each building were developed with FID, MUX and local DTM costs prorated by building. Annual energy cost savings for electricity and natural gas and annual maintenance cost increases were calculated for each building. Finally the Savings to Investment Ratio (SIR) and simple payback in years were calculated for each building and are shown in Table ES.1.

The Low Cost Alternative (LCA) configuration is defined as the distributed control and data environment elements of the EMCS. This results in all the energy savings of the EMCS with the single exception of electrical demand limiting. The same procedures for energy savings calculations, system layout and costing, and economic evaluation were followed for the LSA as for the EMCS. The LCA schematic and building report summary are shown in Figure ES-2 and Table ES.3.

A study of connecting the 10 reimbursable utilities buildings to the EMCS was made. The system schematic and building summary report are shown in Figure ES-3 and Table ES.3 respectively.

A study of implementing an LCA for the reimbursable utilities was made. The system schematic and building summary report are shown in Figure ES-4 and Table ES-4 respectively.

EMCS Results for the O & M Buildings

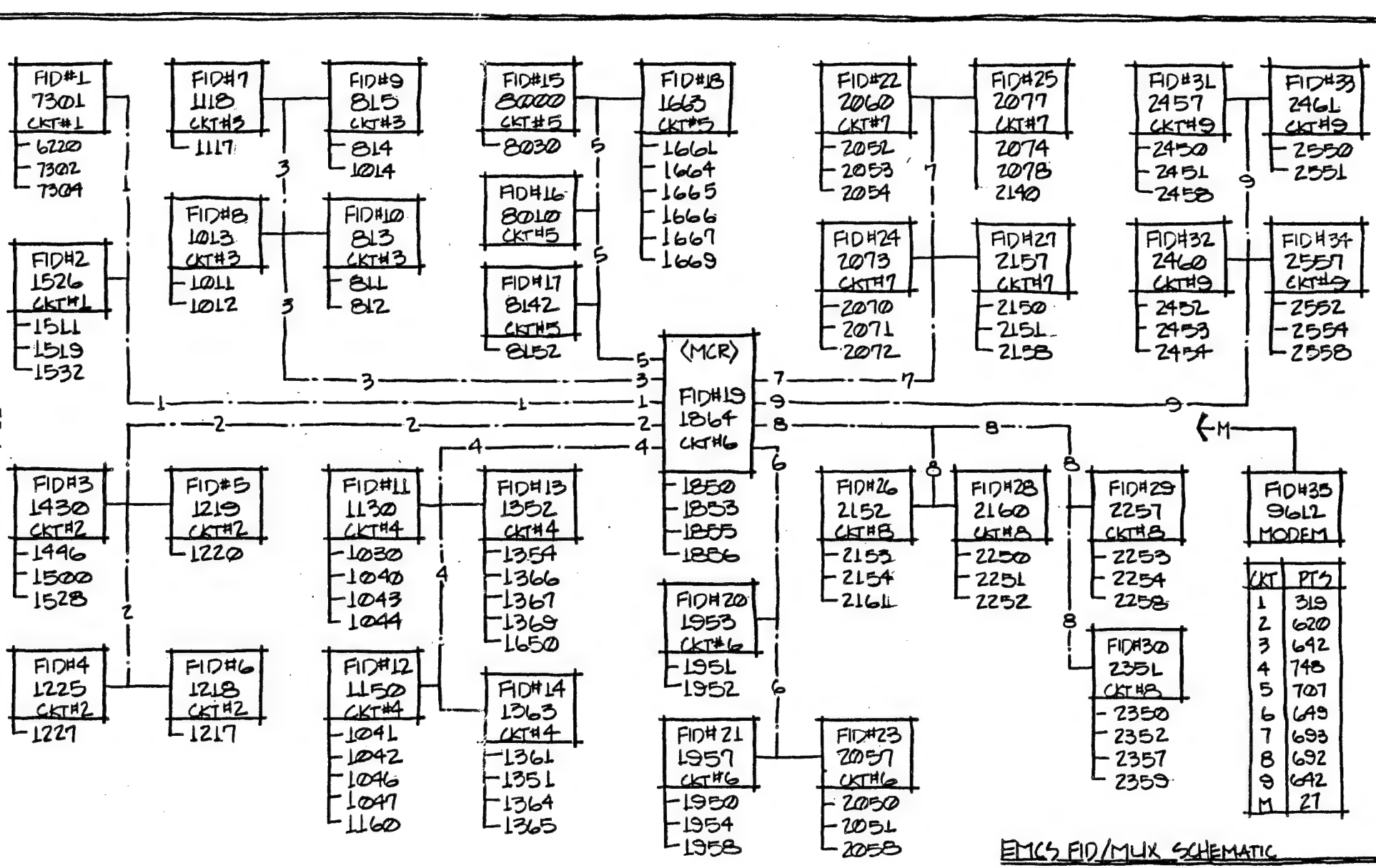
128 buildings qualify under the ECIP criteria and are shown in Figure ES-1. The project is recommended for the FY88 ECIP program, and the project development brochure and DD1391 have been completed and delivered with this report. The main project features are summarized below.

No. of Buildings		128
Length of buried cable		69,700 ft.
No. of line drivers		43
No. of modems		2
No. of FIDs		35
No. of MUX panels		93
No. of DE points		5,739
Annual electrical savings	(MBTU)	37,538
	($)	86,976
Annual natural gas savings	(MBTU)	248,002
	($)	1,064,069
Annual maintenance cost		$ 60,882
Annual electrical demand savings		$ 6,918
Net annual cost savings		$1,097,081
Total EMCS investment cost		$3,879,384
Simple payback period		$3,879,384/$1,097,081 = 3.5 years

$$SIR = \frac{9.42 \times 86,976 + 13.36 \times 1,064,069 - 9.11 \times 53,964}{3,892,962}$$

SIR = 3.7

The performance of the EMCS depends in a major way on the working condition of the local loop control elements. The repair and maintenance of these controls is an ongoing job that must be completed for any system to function properly. Each building was surveyed for broken or damaged controls and actuators to provide a reasonable and probable cost of repair, calibration and adjustment on the EMCS buildings. The estimated repair work cost is established to be $246,671 and should be included in the O&M budget for FY 88.



EMCS FID/MUX SCHEMATIC

FIGURE ES.1

* BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION COST	FID/ MUX COST	TOTAL BLDG COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	BLDG E/C RATIO
8030	118	2,941	19,706	1,340	88,236	17,095	3,450.00	6,251.00	26796	43.4	0.3	845
8000	302	2,178	20,153	1,667	94,905	27,089	3,450.00	2,794.00	33333	37.7	0.4	670
1430	2	37	5,148	718	22,754	7,213	5,750.00	1,397.00	14360	21.4	0.6	361
9612	0	33	4,552	745	20,017	7,933	718.00	6,251.00	14902	18.1	0.7	308
1446	10	256	3,905	801	17,449	5,411	5,750.00	4,854.00	16015	14.6	0.9	260
1040	7	242	2,022	411	8,656	5,957	1,150.00	1,117.00	8224	14.1	1.0	275
1856	31	913	3,102	723	14,212	10,513	1,150.00	2,794.00	14457	12.9	1.0	278
2357	31	913	3,102	841	14,094	10,513	1,916.00	4,388.00	16817	11.0	1.2	239
2460	5	260	2,007	521	8,505	8,446	862.00	1,117.00	10425	10.9	1.2	217
1041	7	242	2,022	645	8,422	5,957	2,084.00	4,854.00	12895	8.8	1.5	176
1369	7	242	2,022	660	8,407	5,957	1,916.00	5,319.00	13192	8.6	1.6	172
1511	38	540	2,702	967	12,421	6,853	6,900.00	5,588.00	19341	8.6	1.6	168
1669	7	242	2,022	669	8,398	5,957	2,108.00	5,319.00	13384	8.5	1.6	169
1957	16	372	1,838	623	7,917	10,533	805.00	1,117.00	12455	8.5	1.6	177
1361	7	242	2,022	674	8,393	5,957	2,204.00	5,319.00	13480	8.4	1.6	168
8142	25	1,043	4,844	1,657	20,910	26,616	3,737.00	2,794.00	33147	8.4	1.6	178
1661	7	242	2,022	679	8,388	5,957	2,300.00	5,319.00	13576	8.3	1.6	167
1526	14	745	2,028	807	9,801	7,872	2,012.00	6,251.00	16135	8.0	1.6	172
2457	16	372	1,838	657	7,883	10,533	1,495.00	1,117.00	13145	8.0	1.7	168
2557	16	372	1,838	657	7,883	10,533	1,495.00	1,117.00	13145	8.0	1.7	168
1217	8	234	4,468	1,673	19,086	28,949	1,725.00	2,794.00	33468	7.8	1.8	140
1650	19	418	2,409	874	10,191	10,380	2,530.00	4,574.00	17484	7.8	1.7	162
2057	21	535	1,791	886	7,952	12,023	766.00	931.00	13720	7.7	1.7	170
2350	5	260	2,007	737	8,289	8,446	1,916.00	4,388.00	14750	7.6	1.8	154
2352	5	260	2,007	737	8,289	8,446	1,916.00	4,388.00	14750	7.6	1.8	154
1519	8	181	1,188	481	5,270	2,884	1,150.00	5,588.00	9622	7.4	1.8	142
2077	21	535	1,791	714	7,924	12,023	1,150.00	1,117.00	14290	7.3	1.8	163
2157	21	535	1,791	715	7,923	12,023	1,341.00	931.00	14295	7.3	1.8	163
1218	8	234	4,468	1,846	18,913	28,949	1,725.00	6,251.00	36925	7.0	2.0	127
1220	8	234	4,468	1,846	18,913	28,949	1,725.00	6,251.00	36925	7.0	2.0	127
1500	5	155	2,562	1,074	10,863	10,870	5,750.00	4,854.00	21474	6.9	2.0	127
2257	21	535	1,791	764	7,874	12,023	1,868.00	1,397.00	15288	6.8	1.9	152
1958	16	372	1,838	796	7,744	10,533	805.00	4,574.00	15912	6.5	2.1	139
1352	28	728	1,617	754	7,532	11,439	2,530.00	1,117.00	15086	6.5	2.0	155
813	36	433	2,004	978	9,034	16,460	1,245.00	1,862.00	19567	6.2	2.2	125
2458	16	372	1,838	830	7,710	10,533	1,495.00	4,574.00	16602	6.2	2.2	133
2558	16	372	1,838	830	7,710	10,533	1,495.00	4,574.00	16602	6.2	2.2	133
1013	36	433	2,004	1,002	9,010	16,460	1,725.00	1,862.00	20047	6.0	2.2	122
2058	21	535	1,791	859	7,779	12,023	766.00	4,388.00	17177	6.0	2.2	135
2078	21	535	1,791	887	7,751	12,023	1,150.00	4,574.00	17747	5.8	2.3	131
2158	21	535	1,791	888	7,750	12,023	1,341.00	4,388.00	17752	5.8	2.3	131
1219	8	132	3,591	1,824	14,774	31,958	1,725.00	2,794.00	36477	5.6	2.5	102
2258	21	535	1,791	937	7,701	12,023	1,868.00	4,854.00	18745	5.5	2.4	124
1532	67	713	2,112	1,214	9,887	15,827	2,875.00	5,588.00	24290	5.4	2.5	116
811	36	433	2,004	1,151	8,861	16,460	1,245.00	5,319.00	23024	5.2	2.6	106
812	36	433	2,004	1,151	8,861	16,460	1,245.00	5,319.00	23024	5.2	2.6	106
2461	16	272	1,192	648	4,968	9,943	1,150.00	1,862.00	12955	5.2	2.6	113
6220	0	0	1,627	893	6,503	11,383	1,150.00	5,319.00	17852	5.1	2.7	91
1011	36	433	2,004	1,175	8,837	16,460	1,725.00	5,319.00	23504	5.1	2.7	104

Table ES.1 (Con't)

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* BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION COST	FID/ MUX COST	TOTAL BLDG COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	R *
1012	36	433	2,004	1,175	8,837	16,460	1,725.00	5,319.00	23504	5.1	2.7	
1117	8	132	3,591	1,997	14,601	31,958	1,725.00	6,251.00	39934	5.1	2.7	
815	5	47	817	462	3,347	5,436	1,006.00	2,794.00	9236	5.0	2.8	
1160	12	204	2,004	1,129	7,817	15,263	1,725.00	5,588.00	22576	4.8	2.9	
1118	1	50	2,733	1,708	10,820	29,649	1,725.00	2,794.00	34168	4.4	3.2	
1663	14	190	2,248	1,344	8,595	23,915	1,840.00	1,117.00	26872	4.4	3.1	
1227	42	840	1,277	950	6,506	11,023	1,725.00	6,251.00	18999	4.4	2.9	
2161	16	262	1,258	827	5,046	10,832	862.00	4,854.00	16548	4.2	3.3	
2060	28	732	1,367	991	6,245	17,635	790.00	1,397.00	19822	4.1	3.2	
2160	28	732	1,367	998	6,238	17,635	934.00	1,397.00	19966	4.1	3.2	
1665	14	190	2,248	1,516	8,423	23,915	1,840.00	4,574.00	30329	3.9	3.6	
1666	14	190	2,248	1,516	8,423	23,915	1,840.00	4,574.00	30329	3.9	3.6	
1667	14	190	2,248	1,516	8,423	23,915	1,840.00	4,574.00	30329	3.9	3.6	
2351	14	362	969	714	4,113	11,439	1,916.00	931.00	14286	3.9	3.5	
2154	6	138	1,667	1,186	6,190	17,999	862.00	4,854.00	23715	3.7	3.8	
7301	0	34	777	573	3,014	8,760	2,012.00	691.00	11463	3.7	3.8	
1951	6	138	1,667	1,214	6,162	17,999	958.00	5,319.00	24276	3.6	3.9	
2554	6	138	1,667	1,203	6,173	17,999	1,495.00	4,574.00	24068	3.6	3.9	
1864	2	13	517	380	1,850	4,138	0.00	3,457.00	7595	3.5	4.1	
1030	17	438	1,130	972	5,013	13,708	1,150.00	4,574.00	19432	3.5	3.9	
1853	28	732	1,367	1,185	6,051	17,635	1,221.00	4,854.00	23710	3.4	3.9	
8152	19	680	2,445	1,998	9,680	29,966	3,737.00	6,251.00	39954	3.3	4.1	
1528	10	217	801	760	3,295	10,391	2,012.00	2,794.00	15197	3.0	4.6	
1225	24	507	1,720	1,643	7,179	28,336	1,725.00	2,794.00	32855	3.0	4.6	
2140	26	475	973	1,010	4,355	11,747	2,875.00	5,588.00	20210	2.9	4.6	
2152	6	96	1,079	1,013	3,782	17,999	862.00	1,397.00	20258	2.7	5.4	
1953	6	96	1,079	1,041	3,754	17,999	958.00	1,862.00	20819	2.6	5.5	
2073	6	96	1,079	1,020	3,775	17,999	1,006.00	1,397.00	20402	2.6	5.4	
8010	27	349	2,278	2,542	8,537	40,654	4,600.00	5,588.00	50842	2.4	6.0	
1014	11	88	710	799	2,622	11,471	1,725.00	2,794.00	15990	2.4	6.1	
1950	6	96	1,079	1,169	3,626	17,999	805.00	4,574.00	23378	2.3	6.4	
1954	6	96	1,079	1,169	3,626	17,999	805.00	4,574.00	23378	2.3	6.4	
2050	6	96	1,079	1,158	3,637	17,999	766.00	4,388.00	23153	2.3	6.4	
2051	6	96	1,079	1,158	3,637	17,999	766.00	4,388.00	23153	2.3	6.4	
1351	19	510	1,297	1,493	4,999	22,761	2,530.00	4,574.00	29865	2.3	6.0	
1363	8	64	1,014	1,104	3,365	19,015	1,955.00	1,117.00	22087	2.2	6.6	
2053	6	96	1,079	1,182	3,613	17,999	790.00	4,854.00	23643	2.2	6.5	
2070	6	96	1,079	1,193	3,602	17,999	1,006.00	4,854.00	23859	2.2	6.6	
2153	6	96	1,079	1,186	3,609	17,999	862.00	4,854.00	23715	2.2	6.6	
2250	6	96	1,079	1,189	3,606	17,999	934.00	4,854.00	23787	2.2	6.6	
1952	6	96	1,079	1,214	3,581	17,999	958.00	5,319.00	24276	2.2	6.8	
2052	6	96	1,079	1,182	3,613	17,999	790.00	4,854.00	23643	2.2	6.5	
2054	6	96	1,079	1,182	3,613	17,999	790.00	4,854.00	23643	2.2	6.5	
2071	6	96	1,079	1,193	3,602	17,999	1,006.00	4,854.00	23859	2.2	6.6	
2072	6	96	1,079	1,193	3,602	17,999	1,006.00	4,854.00	23859	2.2	6.6	
2074	6	96	1,079	1,186	3,609	17,999	1,150.00	4,574.00	23723	2.2	6.6	
2150	6	96	1,079	1,186	3,609	17,999	1,341.00	4,388.00	23728	2.2	6.6	
2151	6	96	1,079	1,186	3,609	17,999	1,341.00	4,388.00	23728	2.2	6.6	
2251	6	96	1,079	1,189	3,606	17,999	934.00	4,854.00	23787	2.2	6.6	

Table ES.1 (Con't)

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* BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION COST	FID/ MUX COST	TOTAL BLDG COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK
2252	6	96	1,079	1,189	3,606	17,999	934.00	4,854.00	23787	2.2	6.6
2450	6	96	1,079	1,203	3,592	17,999	1,495.00	4,574.00	24068	2.2	6.7
2451	6	96	1,079	1,203	3,592	17,999	1,495.00	4,574.00	24068	2.2	6.7
2452	6	96	1,079	1,172	3,623	17,999	862.00	4,574.00	23435	2.2	6.5
2453	6	96	1,079	1,172	3,623	17,999	862.00	4,574.00	23435	2.2	6.5
2454	6	96	1,079	1,172	3,623	17,999	862.00	4,574.00	23435	2.2	6.5
2552	6	96	1,079	1,203	3,592	17,999	1,495.00	4,574.00	24068	2.2	6.7
2253	6	96	1,079	1,236	3,559	17,999	1,868.00	4,854.00	24721	2.1	6.9
2254	6	96	1,079	1,236	3,559	17,999	1,868.00	4,854.00	24721	2.1	6.9
2550	6	96	1,079	1,223	3,572	17,999	1,150.00	5,319.00	24468	2.1	6.8
2551	6	96	1,079	1,223	3,572	17,999	1,150.00	5,319.00	24468	2.1	6.8
1042	8	55	1,074	1,256	3,430	19,015	1,257.00	4,854.00	25126	2.0	7.3
814	0	23	573	749	1,899	7,732	1,006.00	6,251.00	14989	1.9	7.9
1043	8	64	1,014	1,237	3,232	19,015	1,150.00	4,574.00	24739	1.9	7.7
1044	8	64	1,014	1,256	3,213	19,015	1,257.00	4,854.00	25126	1.9	7.8
1047	8	64	1,014	1,256	3,213	19,015	1,257.00	4,854.00	25126	1.9	7.8
1364	8	64	1,014	1,277	3,192	19,015	1,955.00	4,574.00	25544	1.9	8.0
1365	8	64	1,014	1,277	3,192	19,015	1,955.00	4,574.00	25544	1.9	8.0
1366	8	64	1,014	1,277	3,192	19,015	1,955.00	4,574.00	25544	1.9	8.0
1367	8	64	1,014	1,277	3,192	19,015	1,955.00	4,574.00	25544	1.9	8.0
1664	8	64	1,014	1,271	3,198	19,015	1,840.00	4,574.00	25429	1.9	8.0
7304	0	34	866	1,116	2,863	16,170	2,012.00	4,148.00	22330	1.9	7.8
7302	0	34	866	1,116	2,863	16,170	2,012.00	4,148.00	22330	1.9	7.8
1130	0	17	519	675	1,719	11,230	1,150.00	1,117.00	13497	1.9	7.9
1150	8	135	341	459	1,255	5,704	2,084.00	1,397.00	9185	1.9	7.3
1046	8	64	1,014	1,298	3,171	19,015	2,084.00	4,854.00	25953	1.8	8.2
1354	10	143	596	875	2,124	10,397	2,530.00	4,574.00	17501	1.8	8.2
2359	8	102	343	496	1,173	3,613	1,916.00	4,388.00	9917	1.7	8.5
1850	1	49	589	814	1,770	13,664	1,221.00	1,397.00	16282	1.6	9.2
7303	0	35	449	728	1,374	8,400	2,012.00	4,148.00	14560	1.5	10.6
7305	0	35	449	728	1,374	8,400	2,012.00	4,148.00	14560	1.5	10.6
1855	17	508	778	1,343	2,937	19,450	1,150.00	6,251.00	26851	1.5	9.1
1350	2	47	659	981	1,912	12,513	2,530.00	4,574.00	19617	1.5	10.3
1698	7	99	684	1,196	2,116	14,309	4,025.00	5,588.00	23922	1.4	11.3
1045	0	50	713	1,204	1,940	18,348	1,150.00	4,574.00	24072	1.3	12.4
1049	0	50	713	1,264	1,880	18,348	2,084.00	4,854.00	25286	1.2	13.4
1360	0	50	713	1,294	1,850	18,348	2,204.00	5,319.00	25871	1.2	14.0
1370	0	50	713	1,279	1,865	18,348	1,916.00	5,319.00	25583	1.2	13.7
1670	0	50	713	1,289	1,855	18,348	2,108.00	5,319.00	25775	1.2	13.9
1660	0	50	713	1,298	1,846	18,348	2,300.00	5,319.00	25967	1.1	14.1
1048	12	264	428	951	1,394	16,362	1,257.00	1,397.00	19016	1.1	13.6
7300	39	1,230	843	2,562	3,596	48,234	1,150.00	1,862.00	51246	1.0	14.3
9611	4	133	373	830	1,115	13,094	718.00	2,794.00	16606	1.0	14.9
1852	4	217	470	1,097	1,300	15,875	1,221.00	4,854.00	21950	0.9	16.9
1854	7	211	397	948	1,145	12,881	1,221.00	4,854.00	18956	0.9	16.6
2055	3	75	215	513	544	5,103	766.00	4,388.00	10257	0.9	18.9
2056	3	75	215	513	544	5,103	766.00	4,388.00	10257	0.9	18.9
2354	5	123	385	959	914	12,881	1,916.00	4,388.00	19185	0.8	21.0
2455	3	75	215	559	498	5,103	1,495.00	4,574.00	11172	0.8	22.4

Table ES.1 (Con't)

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* BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION COST	FID/ MUX COST	TOTAL BLDG COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	BLD E/ RATI
2456	3	75	215	527	530	5,103	862.00	4,574.00	10539	0.8	19.9	2
2556	3	75	215	559	498	5,103	1,495.00	4,574.00	11172	0.8	22.4	2
1955	3	75	215	524	533	5,103	805.00	4,574.00	10482	0.8	19.7	2
2075	3	75	215	541	516	5,103	1,150.00	4,574.00	10827	0.8	21.0	2
2076	3	75	215	541	516	5,103	1,150.00	4,574.00	10827	0.8	21.0	2
2155	3	75	215	542	515	5,103	1,341.00	4,388.00	10832	0.8	21.0	2
2156	3	75	215	542	515	5,103	1,341.00	4,388.00	10832	0.8	21.0	2
1007	8	119	315	950	722	11,023	1,725.00	6,251.00	18999	0.7	26.3	2
6230	0	0	323	893	576	11,383	1,150.00	5,319.00	17852	0.6	31.0	1
1362	6	124	317	1,115	474	18,231	2,204.00	1,862.00	22297	0.5	47.0	2
1368	6	124	317	1,100	489	18,231	1,916.00	1,862.00	22009	0.5	45.0	2
1668	6	124	317	1,110	479	18,231	2,108.00	1,862.00	22201	0.5	46.3	2
1662	6	124	317	1,120	469	18,231	2,300.00	1,862.00	22393	0.4	47.7	2
1450	4	57	131	685	25	3,102	5,750.00	4,854.00	13706	0.2	548.2	1
	2,157	41,652	261,604	168019	1056440	2,431,718	273,510.00	655,355.00	3360583			

LCA Results for the O & M Buildings

126 buildings qualify under the ECIP criteria for a Low Cost Alternative system. The schematic is shown in Figure ES-2. This system is not recommended for ECIP funding. While it provides almost the same energy savings as the EMCS, it requires the same maintenance effort for the FIDs, MUXs, and the 5712 points in the Data Environment as does the EMCS. Also, it does not provide the many maintenance advantages and system reporting capabilities that the EMCS does. The system features and performance are summarized below.

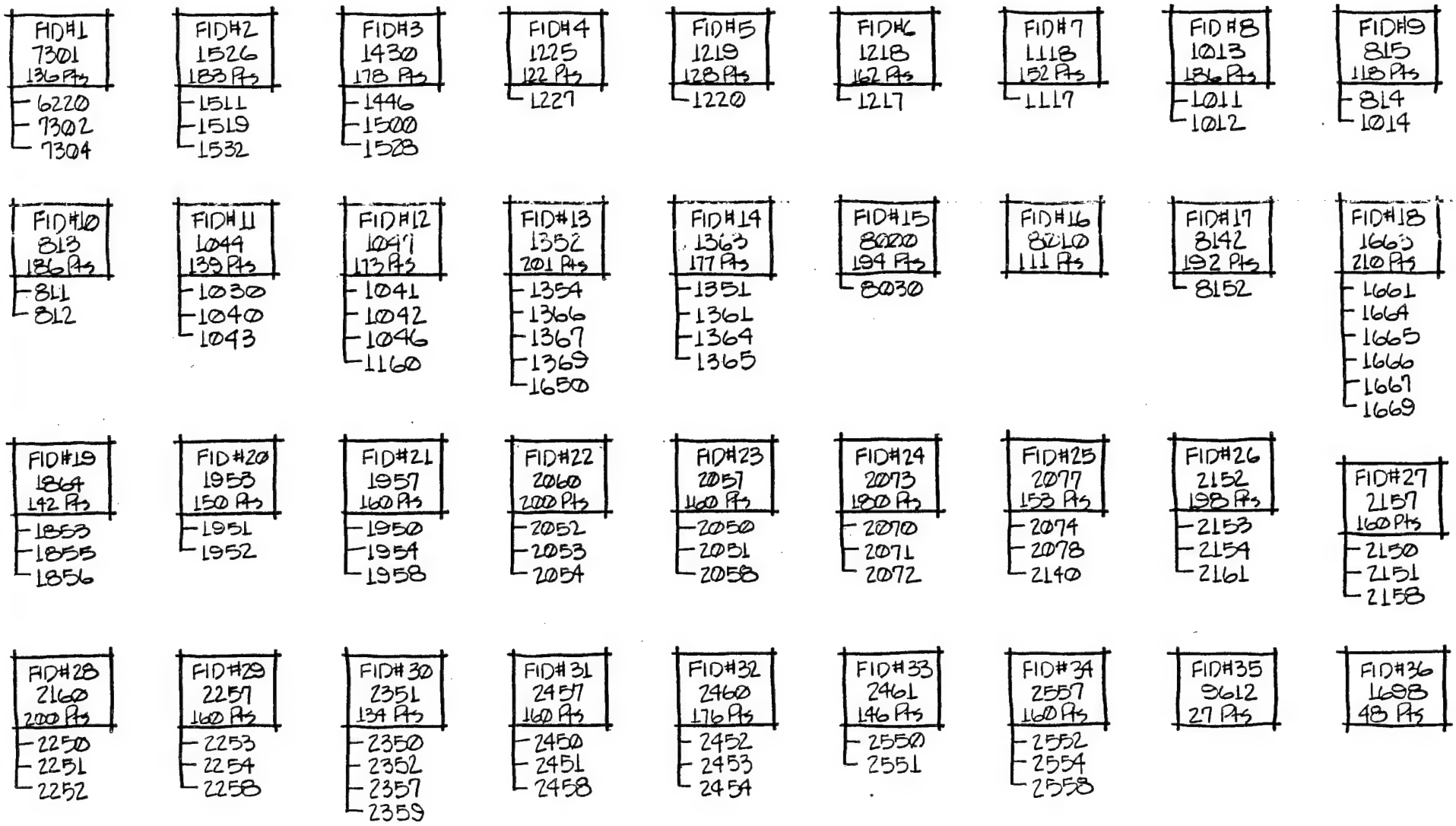
No. of buildings	126	
Length of buried cable	27,110	ft.
No. of line drivers	0	
No. of modems	0	
No. of FIDs	38	
No. of MUX panels	88	
No. of DE points	5,712	
Annual electrical savings	37,434	MBTU/$88,614
Annual natural gas savings	247,237	MBTU/$1,059,374
Annual maintenance cost	$ 148,433	
Net annual savings	$ 851,103	
Total LCA investment cost	$2,968,651	
Simple payback period	3.1	years
SIR	4.6	

Reimbursable Utilities Buildings EMCS Results

This system connects to the large EMCS described above. It is feasible only if the large EMCS is implemented. Although no energy cost savings may be claimed under the ECIP program, certainly the avoided energy costs of such a system should be considered in making the decision whether or not to implement it. Figure ES-3 presents the schematic. Overall features for the 10 buildings are:

No. of FIDs	2	
No. of MUX panels	8	
Length of DTM lines	2,940	ft.
No. of DE points	568	
Annual electrical energy savings	3,337	MBTU/$7,067
Annual natural gas savings	14,306	MBTU/$60,908
Annual maintenance cost	$ 8,997	
Net annual avoided costs	$58,978	
Total investment cost (8/85)	$179,945	
Simple payback period	3.2	years
SIR	4.4	

This system is recommended for connection to the EMCS for the 120 O & M buildings.



LCA FID/MUX SCHEMATIC

FIGURE ES.2

LCA Bui ng Report

* BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION MCR COST	FID/ MUX COST	TOTAL BLDG COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	BLDG E/C RATIO
8030	3	2,941	19,706	1,145	88,024	17,095	216.54	5,588.00	22900	50.7	0.3	989
8030	6	2,178	20,153	1,658	93,874	27,089	483.60	5,588.00	33161	37.6	0.4	673
1446	0	256	3,905	454	17,762	5,411	884.76	2,794.00	9090	26.1	0.5	458
1430	0	37	5,142	648	22,818	7,213	151.57	5,588.00	12953	23.7	0.6	400
9612	0	33	4,552	750	20,012	7,933	816.19	6,251.00	15000	18.0	0.7	306
1511	0	540	2,702	523	12,735	6,853	147.97	3,457.00	10458	16.1	0.8	310
1856	3	913	3,102	638	14,191	10,513	1,458.64	798.28	12770	14.6	0.9	314
1519	0	181	1,188	321	5,403	2,884	86.61	3,457.00	6428	11.2	1.2	213
2357	3	913	3,102	839	13,990	10,513	1,869.36	4,388.33	16771	11.0	1.2	239
1661	3	242	2,022	563	8,480	5,957	1,337.55	3,965.00	11260	10.1	1.3	201
1361	3	242	2,022	563	8,480	5,957	1,337.55	3,965.00	11260	10.1	1.3	201
1369	3	242	2,022	563	8,480	5,957	1,337.55	3,965.00	11260	10.1	1.3	201
1669	3	242	2,022	563	8,480	5,957	1,337.55	3,965.00	11260	10.1	1.3	201
1040	3	242	2,022	572	8,471	5,957	1,586.85	3,886.84	11431	10.0	1.3	198
1041	3	242	2,022	572	8,471	5,957	1,586.85	3,886.84	11431	10.0	1.3	198
1500	0	155	2,562	830	11,090	10,870	137.14	5,588.00	16595	9.1	1.5	164
1650	0	418	2,409	806	10,197	10,380	144.36	5,588.00	16112	8.5	1.6	175
8142	0	1,043	4,844	1,628	20,854	26,616	353.68	5,588.00	32558	8.5	1.6	181
1957	3	372	1,838	624	7,861	10,533	1,258.27	698.50	12490	8.4	1.6	177
2457	3	372	1,838	635	7,850	10,533	1,603.27	558.80	12695	8.3	1.6	174
1526	3	745	2,028	787	9,773	7,872	1,625.16	6,251.00	15748	8.2	1.6	176
2557	3	372	1,838	642	7,843	10,533	1,617.64	698.50	12849	8.2	1.6	172
2460	3	260	2,007	703	8,306	8,446	1,588.83	4,015.80	14051	8.0	1.7	161
2057	3	535	1,791	680	7,686	12,023	1,028.27	558.80	13610	7.7	1.7	171
2350	0	260	2,007	733	8,276	8,446	1,818.83	4,388.33	14653	7.6	1.8	155
2352	0	260	2,007	733	8,276	8,446	1,818.83	4,388.33	14653	7.6	1.8	155
2257	3	535	1,791	699	7,867	12,023	1,258.27	698.50	13980	7.5	1.8	166
1217	3	234	4,468	1,741	18,991	28,949	292.33	5,588.00	34829	7.4	1.8	135
1218	3	234	4,468	1,741	18,991	28,949	292.33	5,588.00	34829	7.4	1.8	135
2157	3	535	1,791	703	7,863	12,023	1,488.27	558.80	14070	7.4	1.8	165
1220	9	234	4,468	1,802	18,930	28,949	2,247.33	4,854.00	36050	7.2	1.9	130
2077	3	535	1,791	728	7,838	12,023	1,977.02	558.80	14559	7.1	1.9	160
1532	3	713	2,112	976	9,895	15,827	238.19	3,457.00	19522	6.7	2.0	145
1352	3	726	1,617	733	7,457	11,439	1,818.83	1,397.00	14655	6.6	2.0	160
1958	3	372	1,838	797	7,688	10,533	1,258.27	4,155.50	15947	6.5	2.1	139
2458	3	372	1,838	808	7,677	10,533	1,603.27	4,015.80	16152	6.4	2.1	137
2558	3	372	1,838	815	7,670	10,533	1,617.64	4,155.50	16306	6.3	2.1	136
815	3	47	617	387	3,485	5,436	1,186.57	1,117.60	7740	6.0	2.3	112
2058	3	535	1,791	853	7,713	12,023	1,028.27	4,015.80	17067	6.0	2.2	136
2158	3	535	1,791	876	7,690	12,023	1,488.27	4,015.80	17527	5.9	2.3	133
2258	3	535	1,791	872	7,694	12,023	1,258.27	4,155.50	17437	5.9	2.3	133
2078	3	535	1,791	901	7,665	12,023	1,977.02	4,015.80	18016	5.7	2.4	129
1117	0	132	3,591	1,891	14,680	31,958	277.89	5,588.00	37824	5.4	2.6	98
6220	3	0	1,627	846	6,550	11,383	1,373.14	4,155.50	16912	5.4	2.6	96
1011	0	433	2,004	1,115	8,773	16,460	1,258.75	4,574.60	22293	5.3	2.5	109
811	3	433	2,004	1,115	8,773	16,460	1,258.75	4,574.60	22293	5.3	2.5	109
812	3	433	2,004	1,115	8,773	16,460	1,258.75	4,574.60	22293	5.3	2.5	109
813	3	433	2,004	1,115	8,773	16,460	1,258.75	4,574.60	22293	5.3	2.5	109
1012	3	433	2,004	1,115	8,773	16,460	1,258.75	4,574.60	22293	5.3	2.5	109

Table [illegible]2 (Con't)

LCA Building Report

* BLDG NO	DEVICE SAVED KJ	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION MCR COST	FID/ MUX COST	TOTAL BLDG COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	BLDG E/C RATIO
1013	0	463	2,004	1,115	8,773	16,460	1,258.75	4,574.60	22293	5.3	2.5	119
1219	3	132	3,591	1,952	14,619	31,958	2,232.89	4,854.00	39045	5.2	2.7	95
1168	6	204	2,304	1,053	7,855	15,263	151.57	5,588.00	21003	5.1	2.7	105
1227	3	340	1,277	698	6,413	11,023	2,099.36	4,854.00	17976	4.8	2.8	116
1116	0	50	2,733	1,775	10,758	29,649	270.67	5,588.00	35506	4.2	3.3	78
2161	0	262	1,258	820	4,999	10,832	1,553.23	4,015.80	16401	4.2	3.3	93
2461	0	272	1,192	789	4,773	9,943	1,675.39	4,155.50	15774	4.1	3.3	93
1663	0	190	2,248	1,462	8,429	23,915	1,370.03	3,965.00	29250	4.0	3.5	83
1665	0	196	2,248	1,462	8,429	23,915	1,370.03	3,965.00	29250	4.0	3.5	83
1666	0	190	2,248	1,462	8,429	23,915	1,370.03	3,965.00	29250	4.0	3.5	83
1667	0	196	2,248	1,462	8,429	23,915	1,370.03	3,965.00	29250	4.0	3.5	83
2351	0	362	969	709	4,070	11,439	1,818.83	931.33	14189	3.9	3.5	94
1951	0	138	1,667	1,174	6,184	17,999	1,330.45	4,155.50	23485	3.7	3.6	77
2154	0	138	1,667	1,179	6,179	17,999	1,560.45	4,015.80	23575	3.7	3.8	77
8152	0	680	2,445	1,795	9,818	29,966	339.24	5,588.00	35893	3.7	3.7	87
2554	0	138	1,667	1,192	6,166	17,999	1,689.82	4,155.50	23844	3.6	3.9	76
1030	0	438	1,130	963	4,964	13,758	1,662.64	3,386.84	19257	3.5	3.9	81
2060	0	732	1,367	1,138	6,002	17,635	1,100.45	4,015.80	22751	3.5	3.8	92
1853	0	732	1,367	1,169	5,971	17,635	1,494.73	4,255.28	23385	3.4	3.9	90
2160	0	732	1,367	1,156	5,984	17,635	1,330.45	4,155.50	23121	3.4	3.9	91
2140	0	475	973	889	4,387	11,747	2,023.93	4,015.80	17787	3.3	4.1	81
1524	0	217	861	740	3,280	10,391	1,625.16	2,794.00	14810	3.1	4.5	69
1225	0	567	1,720	1,599	7,141	28,336	2,250.94	1,697.00	31984	3.1	4.5	70
7301	0	34	777	716	2,871	8,760	1,402.02	4,155.50	14316	2.9	5.0	57
1014	0	62	710	689	2,694	11,471	1,201.01	1,117.60	13790	2.8	5.1	58
8513	0	349	2,278	2,332	8,655	40,654	400.60	5,588.00	46643	2.6	5.4	56
1364	0	13	517	487	1,736	4,138	1,350.37	4,255.28	9744	2.6	5.6	54
2053	0	96	1,079	1,156	3,621	17,999	1,100.45	4,015.80	23115	2.3	6.4	51
2050	0	96	1,079	1,156	3,621	17,999	1,100.45	4,015.80	23115	2.3	6.4	51
2051	0	96	1,079	1,156	3,621	17,999	1,100.45	4,015.80	23115	2.3	6.4	51
2052	0	96	1,079	1,156	3,621	17,999	1,100.45	4,015.80	23115	2.3	6.4	51
2054	0	96	1,079	1,156	3,621	17,999	1,100.45	4,015.80	23115	2.3	6.4	51
1351	0	510	1,297	1,475	4,952	22,761	1,891.01	4,854.00	29506	2.3	6.0	61
1950	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50
2070	0	96	1,079	1,203	3,574	17,999	2,049.20	4,015.80	24064	2.2	6.7	49
2153	0	96	1,079	1,179	3,598	17,999	1,560.45	4,015.80	23575	2.2	6.6	50
2250	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50
1952	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50
1953	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50
1954	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50
2071	0	96	1,079	1,203	3,574	17,999	2,049.20	4,015.80	24064	2.2	6.7	49
2072	0	96	1,079	1,203	3,574	17,999	2,049.20	4,015.80	24064	2.2	6.7	49
2073	0	96	1,079	1,203	3,574	17,999	2,049.20	4,015.80	24064	2.2	6.7	49
2074	0	96	1,079	1,203	3,574	17,999	2,049.20	4,015.80	24064	2.2	6.7	49
2150	0	96	1,079	1,179	3,598	17,999	1,560.45	4,015.80	23575	2.2	6.6	50
2151	0	96	1,079	1,179	3,598	17,999	1,560.45	4,015.80	23575	2.2	6.6	50
2152	0	96	1,079	1,179	3,598	17,999	1,560.45	4,015.80	23575	2.2	6.6	50
2251	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50
2252	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50

Table E[illegible] (Con't)

LCA Buil[illegible]g Report

* BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION MCR COST	FID/ MUX COST	TOTAL BLDG COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	BLDG E/C RATIO
2253	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50
2254	0	96	1,079	1,174	3,603	17,999	1,330.45	4,155.50	23485	2.2	6.5	50
2450	0	96	1,079	1,184	3,593	17,999	1,675.45	4,015.80	23690	2.2	6.6	50
2451	0	96	1,079	1,184	3,593	17,999	1,675.45	4,015.80	23690	2.2	6.6	50
2452	0	96	1,079	1,184	3,593	17,999	1,675.45	4,015.80	23690	2.2	6.6	50
2453	0	96	1,079	1,184	3,593	17,999	1,675.45	4,015.80	23690	2.2	6.6	50
2454	0	96	1,079	1,184	3,593	17,999	1,675.45	4,015.80	23690	2.2	6.6	50
2550	0	96	1,079	1,192	3,585	17,999	1,689.82	4,155.50	23844	2.2	6.7	49
2551	0	96	1,079	1,192	3,585	17,999	1,689.82	4,155.50	23844	2.2	6.7	49
2552	0	96	1,079	1,192	3,585	17,999	1,689.82	4,155.50	23844	2.2	6.7	49
814	0	23	573	672	1,976	7,732	1,143.27	4,574.60	13450	2.2	6.8	44
1042	0	55	1,074	1,227	3,431	19,015	1,633.77	3,886.84	24536	2.1	7.2	46
1363	0	64	1,014	1,218	3,223	19,015	1,384.47	3,965.00	24364	2.0	7.6	44
1364	0	64	1,014	1,218	3,223	19,015	1,384.47	3,965.00	24364	2.0	7.6	44
1365	0	64	1,014	1,218	3,223	19,015	1,384.47	3,965.00	24364	2.0	7.6	44
1366	0	64	1,014	1,218	3,223	19,015	1,384.47	3,965.00	24364	2.0	7.6	44
1367	0	64	1,014	1,218	3,223	19,015	1,384.47	3,965.00	24364	2.0	7.6	44
1664	0	64	1,014	1,218	3,223	19,015	1,384.47	3,965.00	24364	2.0	7.6	44
7304	0	34	866	1,089	2,890	16,170	1,445.32	4,155.50	21771	2.0	7.5	41
7302	0	34	866	1,089	2,890	16,170	1,445.32	4,155.50	21771	2.0	7.5	41
1698	0	99	684	897	2,391	14,309	173.23	3,457.00	17939	2.0	7.5	44
1043	0	64	1,014	1,227	3,214	19,015	1,633.77	3,886.84	24536	1.9	7.6	44
1044	0	64	1,014	1,227	3,214	19,015	1,633.77	3,886.84	24536	1.9	7.6	44
1046	0	64	1,014	1,227	3,214	19,015	1,633.77	3,886.84	24536	1.9	7.6	44
1047	0	64	1,014	1,227	3,214	19,015	1,633.77	3,886.84	24536	1.9	7.6	44
1354	0	143	596	856	2,108	10,397	1,869.36	4,854.00	17120	1.8	8.1	43
2359	0	102	343	489	1,152	3,613	1,782.74	4,388.33	9784	1.7	8.5	45
1855	0	508	778	1,259	2,963	19,450	1,465.86	4,255.28	25171	1.6	8.5	51
7303	0	35	449	699	1,403	8,400	1,430.89	4,155.50	13986	1.5	10.0	35
7305	0	35	449	699	1,403	8,400	1,430.89	4,155.50	13986	1.5	10.0	35
1151	0	135	341	559	1,128	5,704	1,590.46	3,886.84	11181	1.5	9.9	43
1356	0	47	659	960	1,926	12,513	1,826.05	4,854.00	19193	1.5	10.0	37
1133	0	17	519	837	1,557	11,230	1,626.55	3,886.84	16743	1.4	10.8	32
1045	0	50	713	1,194	1,950	18,348	1,640.98	3,886.84	23876	1.3	12.2	32
1049	0	50	713	1,194	1,950	18,348	1,640.98	3,886.84	23876	1.3	12.2	32
1360	0	50	713	1,185	1,959	18,348	1,391.68	3,965.00	23705	1.3	12.1	32
1370	0	50	713	1,185	1,959	18,348	1,391.68	3,965.00	23705	1.3	12.1	32
1660	0	50	713	1,185	1,959	18,348	1,391.68	3,965.00	23705	1.3	12.1	32
1670	0	50	713	1,185	1,959	18,348	1,391.68	3,965.00	23705	1.3	12.1	32
1850	0	49	589	968	1,613	13,664	1,447.81	4,255.28	19367	1.3	12.0	33
1048	0	264	428	923	1,381	16,362	1,669.86	429.84	18462	1.1	13.4	37
7306	0	1,253	843	2,536	3,495	48,234	1,665.47	698.50	50598	1.0	14.5	41
1854	0	211	397	928	1,141	12,881	1,418.94	4,255.28	18555	1.0	16.3	33
9611	0	133	373	836	1,095	13,094	841.45	2,794.00	16729	1.0	15.3	30
1852	0	217	479	1,080	1,303	15,875	1,462.25	4,255.28	21593	0.9	16.6	32
2055	0	75	215	506	541	5,103	992.18	4,015.80	10111	0.9	18.7	29
2056	0	75	215	506	541	5,103	992.18	4,015.80	10111	0.9	18.7	29
1307	0	119	315	869	806	11,023	1,179.36	4,574.60	16777	0.8	20.8	26
2354	0	123	385	995	901	12,881	1,833.27	4,388.33	19103	0.8	21.2	27

Table E[illegible] (Con't)

LCA Building Report

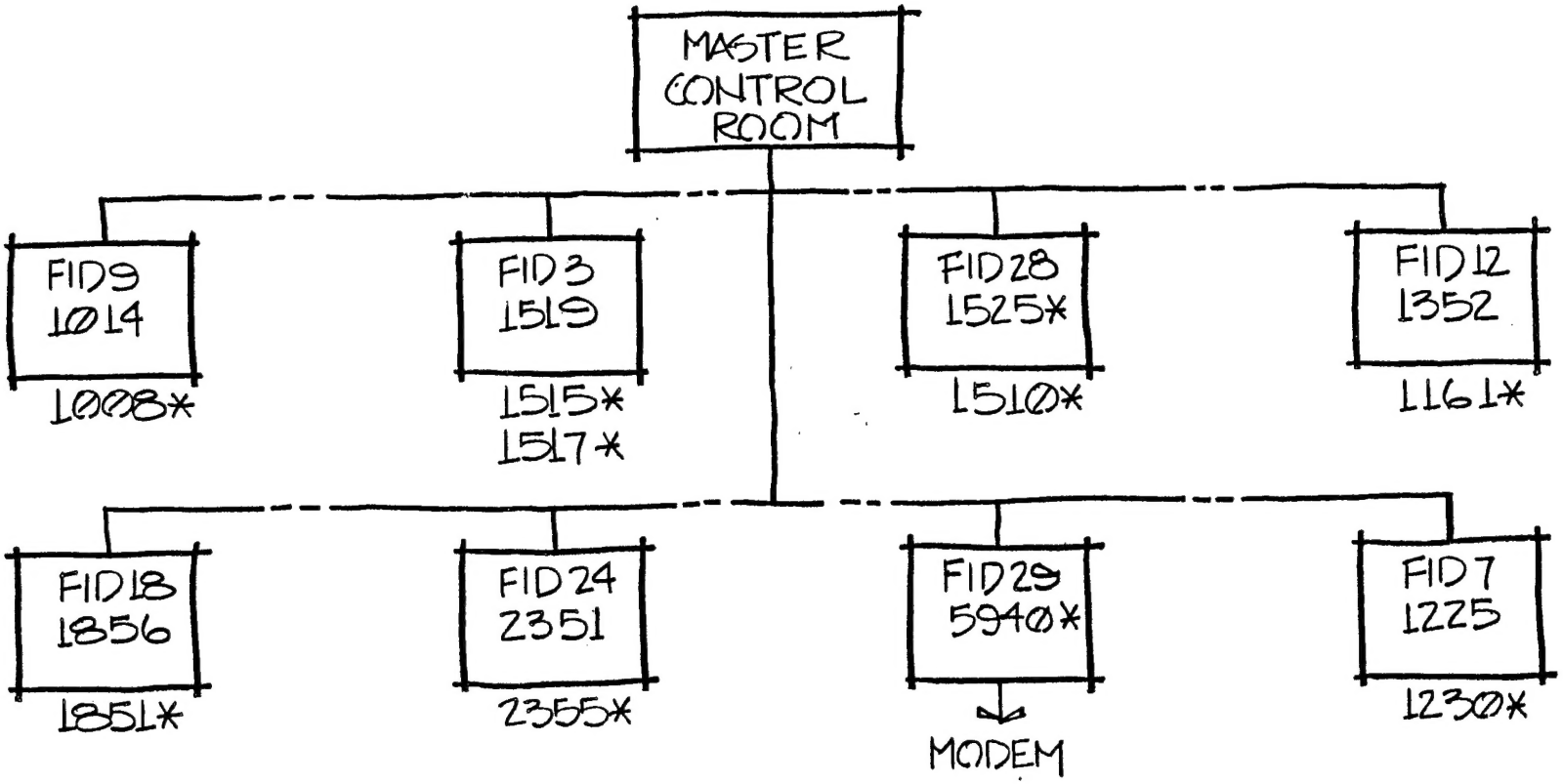
* BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION MCR COST	FID/ MUX COST	TOTAL BLDG COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	BLDG E/C RATIO
2455	0	75	215	534	513	5,103	1,567.18	4,015.80	10686	0.8	20.8	27
2456	0	75	215	534	513	5,103	1,567.18	4,015.80	10686	0.8	20.8	27
2556	0	75	215	542	505	5,103	1,581.55	4,155.50	10840	0.8	21.5	27
1955	0	75	215	524	523	5,103	1,222.18	4,155.50	10481	0.8	20.0	28
2075	0	75	215	553	494	5,103	1,940.93	4,015.80	11060	0.8	22.4	26
2076	0	75	215	553	494	5,103	1,940.93	4,015.80	11060	0.8	22.4	26
2155	0	75	215	529	518	5,103	1,452.18	4,015.80	10571	0.8	20.4	27
2156	0	75	215	529	518	5,103	1,452.18	4,015.80	10571	0.8	20.4	27
6230	0	0	323	846	623	11,383	1,373.14	4,155.50	16912	0.7	27.1	19
1368	0	124	317	1,009	560	18,231	1,449.43	508.00	20188	0.5	36.0	22
1668	0	124	317	1,009	560	18,231	1,449.43	508.00	20188	0.5	36.0	22
1362	0	124	317	1,182	387	18,231	1,449.43	3,965.00	23645	0.4	61.1	19
1662	0	124	317	1,182	387	18,231	1,449.43	3,965.00	23645	0.4	61.1	19
1459	0	57	131	510	186	3,102	841.45	6,251.00	10194	0.4	54.8	18
	0	41,652	261,604	163923	1053224	2,431,718	220,006.92	626,899.86	3278622			

Reimbursable Utilities Buildings LCA Results

This system is feasible providing that an EMCS or LCA is installed on the O & M buildings. The energy cost savings are actually avoided costs, and are provided for use in decision making. The schematic is shown in Figure ES-4. The features are summarized below:

No. of FIDs	3	
No. of MUX panels	6	
Feet of DTM	1,440	ft.
No. of DE points	568	
Annual electrical energy savings	3,337	MBTU/$6,036
Annual natural gas savings	14,306	MBTU/$60,908
Annual maintenance cost	$ 8,694	
Net annual avoided costs	$58,250	
Total investment cost	$173,889	
Simple payback period	3.1	years
SIR	4.5	

This system is not recommended if an EMCS is installed on the 128 qualifying buildings. It is recommended if the LCA system is installed on the 126 qualifying buildings.



REIMBURSABLE UTILITIES BUILDINGS

EMCS SCHEMATIC FIGURE ES-3

* DENOTES REIMBURSABLE UTILITIES BUILDINGS

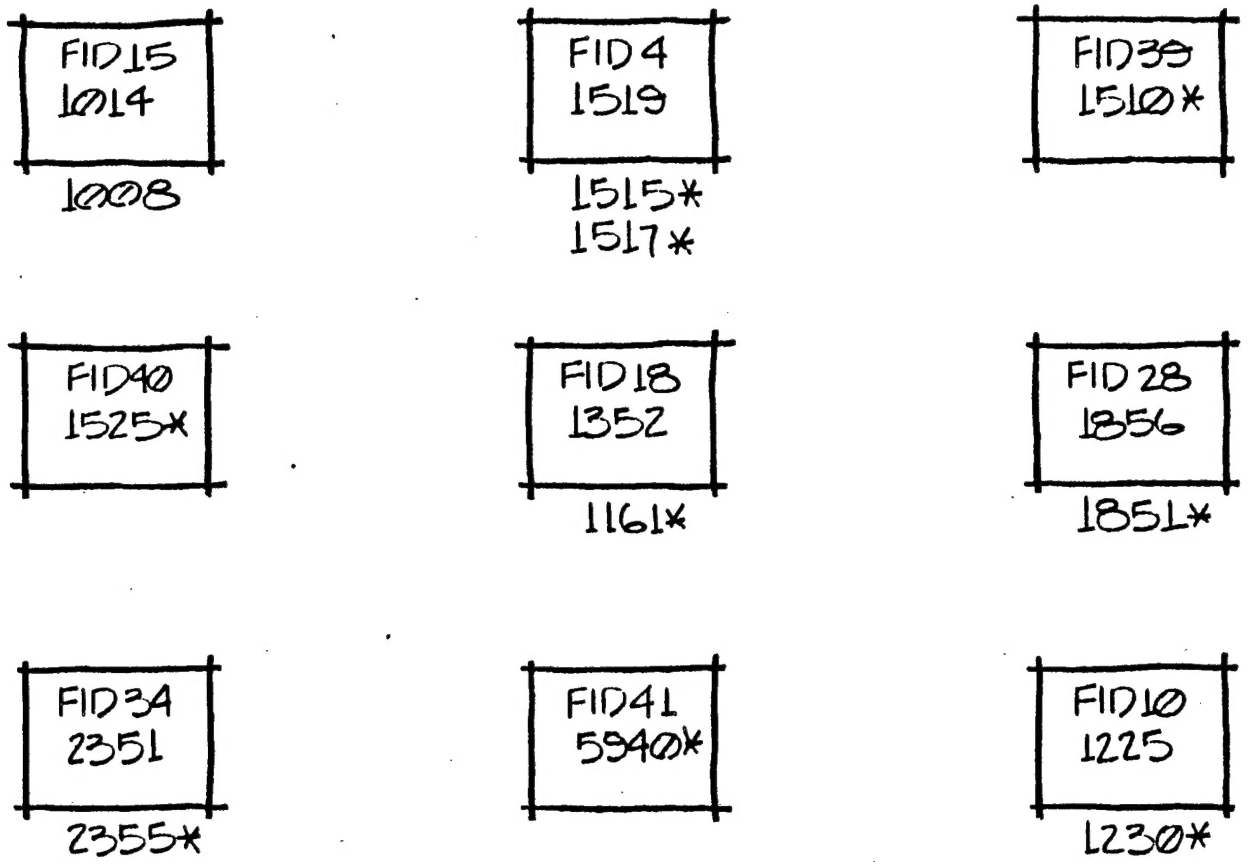
— - - — DENOTES DATA TRANSMISSION MEDIA

Table ES.3
EMCS Building Report
Reimbursable Utilities Group

BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION MCR COST	FID/ MUX COST	TOTAL BLDG. COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	BLDG E/C RATIO
****	******	*****	*****	******	*******	******	**********	****	*****	****	*******	*****
1510	136	1,132	5,719	1,646	25,196	23,507	3,163	6,251	32,920	13.3	1.3	208
1525	81	592	3,564	1,233	15,271	18,703	3,163	2,794	24,659	10.2	1.6	169
1230	60	826	1,754	1,228	7,918	19,156	1,955	3,457	24,568	7.5	3.1	105
1517	23	207	1,345	859	5,312	11,712	2,013	3,457	17,181	5.2	3.2	90
2355	7	168	745	513	2,980	4,502	2,300	3,457	10,259	4.0	3.4	89
1008	10	137	400	492	1,487	4,662	1,725	3,457	9,844	2.6	6.6	55
5940	6	144	306	411	1,175	4,220	546	3,457	8,223	2.1	7.0	55
1161	6	131	473	653	1,601	9,323	287	3,457	13,067	2.0	8.2	46
1851	4	83	342	544	1,071	7,146	287	3,457	10,890	1.7	10.2	39
1515	3	33	196	462	446	3,776	2,012	3,457	9,245	0.9	20.7	25
	336	3,453	14,844	8,041	62,457	106,707	17,451	36,701	160,856			

Table ES.4
Low Cost Alternative Building Report
Reimbursable Utilities Group

BLDG NO	DEMAND SAVED KW	ELECT SAVED MBTU	N GAS SAVED MBTU	ANNUAL MAINT COST	NET DOLLARS SAVED	TOTAL DEVICE COST	DATA TRANSMISSION MCR COST	FID/ MUX COST	TOTAL BLDG. COST	BLDG ECON SIR	BLDG SIMPLE PAYBACK	BLDG E/C RATIO
1510	0	1,132	5,719	1,455	24,919	23,507	0	5,588	29,095	14.1	1.2	235
1525	0	592	3,564	1,215	15,011	18,703	0	5,588	24,291	9.9	1.6	171
1230	0	826	1,754	1,228	7,712	19,156	1,956	3,457	24,568	7.1	3.2	105
1517	0	207	1,345	859	5,232	11,712	2,011	3,457	17,181	5.0	3.3	90
2355	0	168	745	504	2,965	4,502	0	5,588	10,090	4.0	3.4	90
1008	0	137	400	492	1,453	4,662	1,725	3,457	9,844	2.5	6.8	55
5940	0	144	306	384	1,182	4,220	0	3,457	7,677	2.3	6.5	59
1161	0	131	473	653	1,580	9,323	288	3,457	13,067	2.0	8.3	46
1851	0	83	342	544	1,058	7,146	288	3,457	10,890	1.6	10.3	39
1515	0	33	196	462	436	3,776	2,011	3,457	9,245	0.8	21.2	25
	0	3,453	14,844	7,796	61,548	106,707	8,279	40,963	155,948			



REIMBURSABLE UTILITIES BUILDINGS

LCA SCHEMATIC FIGURE ES-4

* DENOTES REIMBURSABLE UTILITIES BUILDINGS